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A New Theory on VHF Radio Wave Propagation

A NEW theory for the propagation of VHF radio waves beyond the horizon has been announced by the National Bureau of Standards. The theory, developed by Dr. J. Feinstein of the NBS staff, not only accounts for VHF and microwave signals that have been observed at distances beyond the horizon but explains the natural and inevitable—as against "unusual" or "accidental"—occurrence of such transmission. The theory has significant practical implications with respect to television and other high-frequency communication services.

The radio waves concerned have a wavelength of around 3 meters or less, corresponding to frequencies of 100 megacycles or higher. Their transmission has been referred to as "line-of-sight," or optical, because these waves travel largely like light waves in a straight line. This has meant that the general limit of transmission range is just beyond the optical horizon. The over-the-horizon range is determined by the theory that considers the earth's radius—with respect to radio waves—as being four-thirds the actual radius of the earth. This results from bending of the rays in the earth's atmosphere. However, usable signals have been observed well beyond the radio-optical horizon—200 to 400 miles from the transmitter—more often than could be attributed to anomalous conditions in the atmosphere.

Signals far beyond the radio-optical horizon have been explained by previous theories on the basis of unusual meteorological conditions or unusual inhomogeneities in the density of the atmosphere. For example, some investigators have explained the phenomenon by the presence of "ducts", or "channels", in the atmosphere having a density that differs from the air above and below. Such theories have not accounted fully for the regularity of the phenomenon.

The theory developed at NBS suggests a new role for the gradual change in the refractive index of the atmosphere with height. This change, or gradient, leads to reflection as well as refraction of VHF waves as they travel out into space from the transmitter. The amount of reflection is small, but it is enough to lead to appreciable propagation of signals beyond the horizon.

This gradient-reflection theory appears to be corroborated in regard to frequency, angle dependence, range, and similar factors, by research at NBS and other laboratories. However, the new ideas are related to existing theories because all are based on the same fundamental hypothesis. This hypothesis assumes the earth to be a perfectly smooth sphere possessing an atmosphere that gives rise to a refractive index that changes exponentially with height. Several apparently minor approximations are necessary to adapt the ideal model to the conditions that actually apply. In light of the newer theory, there is a strong suspicion that these approximations have a much larger effect than previously assumed. Thus, efforts are being made at NBS to develop a more complete theory that will justify the approximations or, alternately, to develop a new model that can be relied upon to predict propagation characteristics during any season and under all atmospheric conditions.

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Further experimental verification will be sought using new NBS transmitters located at an altitude of 9,000 feet on Cheyenne Mountain in Colorado and extra-sensitive receiving equipment placed on the gradually sloping plains eastward from the site.

The implications of the NBS theory are many. For example, radio communication at longer ranges than line-of-sight now appears feasible at very high frequencies. This increases the possibilities for such communication service as aircraft-to-ground transmission and mobile radio telephony. It means, also, that high-powered TV stations located farther apart than line-of-sight distance will very likely interfere with each other. Thus the problem of allocating television channels will become increasingly complicated.

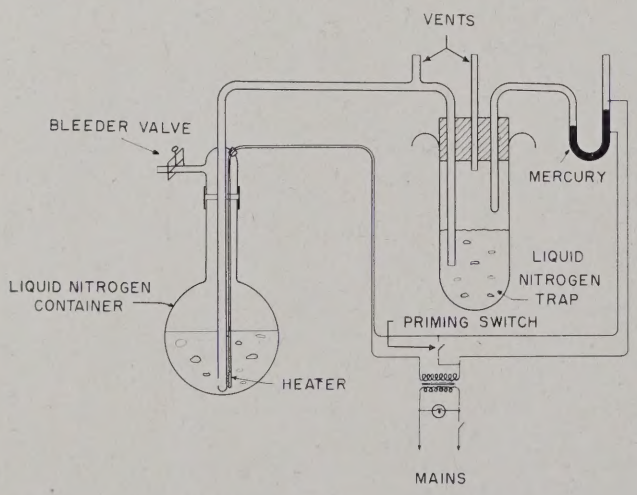
An Automatic Liquid-Nitrogen Dispenser

A VERY simple method for automatically dispensing liquid nitrogen to vacuum-system traps and other vessels has recently been developed by Jesse Sherwood of the National Bureau of Standards. The new technique permits the maintenance of a liquid refrigerant in a system for long periods of time without the use of an external source of compressed air.

In most vacuum systems, the evacuated apparatus is kept free of contaminating gaseous matter by trapping the vapors before they circulate throughout the system. A trap, filled with some refrigerant such as dry ice or liquid nitrogen, is inserted into the system so that as the vapors pass over it, they condense and collect on the surface of the trap. However, these refrigerants evaporate rapidly and hence must be replenished at regular intervals. The NBS dispenser automatically performs this task, keeping the trap filled to any predetermined level for a period of time dependent only on the available supply of liquid nitrogen.

The NBS automatic dispensing technique utilizes two simple principles: that a confined liquid, when heated, will partially evaporate and thereby raise the internal pressure of the container high enough to force the liquid through any prepared orifice; and that a mercury column, besides being sensitive to changes in pressure, is also a conductor of electricity. Thus the dispenser consists essentially of a simple gas thermometer, a mercury pressure gage, a confined source of liquid nitrogen, and a nichrome-wire heater.

The gas thermometer, suspended in the trap, reacts to the temperature at some point near the desired level of liquid nitrogen. If the liquid nitrogen level is low, the gas (air) in the thermometer expands and forces mercury to flow in a U-tube. A pair of wires is preset in the mercury column so that as the mercury surface rises (with the rise in temperature and pressure) the external electric circuit between the two wires is completed. This switching effect applies 25 watts of power to a nichrome-wire heater at the bottom of the liquid-nitrogen container. The ensuing evap-



Schematic diagram of the NBS liquid-nitrogen dispenser. Expansion and contraction of air confined in a gas thermometer (closed tube at right in trap) forces mercury in and out of a U-tube (right). Two wires in the mercury column are preset so that when the mercury is at a certain height, an electric circuit is completed and power flows to a nichrome-wire heater submerged in a liquid-nitrogen container (left). The ensuing evaporation causes an increase in pressure within the container and forces liquid nitrogen into a delivery tube connected to the trap. When the temperature drops to the proper level, the action automatically stops.

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oration generates gaseous nitrogen, and the subsequent increase in pressure forces the liquid nitrogen through a connecting tube to the trap. As the level of the liquid in the trap rises, the thermometer cools, the gas pressure decreases, the mercury column in the U-tube drops, the electric circuit is disconnected, and the flow of liquid nitrogen stops.

A vent in the delivery tube prevents excessive bubbling of the liquid in the trap. A bleeder valve on the liquid-nitrogen container is also provided to remove gaseous nitrogen resulting from natural evaporation; adjustment of this valve is not critical. The U-tube should have an inner diameter of at least 6 millimeters.

Loran Navigation Tables

ABOUT 10 years ago, the Bureau inaugurated a project sponsored by the Navy Department devoted to the preparation of tables for the newly adopted Loran system of navigation. Since that time, the NBS computation laboratory has had the sole responsibility for developing and computing material for tabular presentation. The Navy Hydrographic Office publishes the tables for the Navy Department and also distributes them to the U. S. Air Force and the U. S. Maritime Service. More than 100 tables, involving some 5,000 pages, have been prepared to provide Loran coverage for all the principally traveled areas and important military installations in the world.

At first, NBS used desk calculators to compute Loran tables, and the concerted efforts of some 30 computers were needed to complete an individual table in 2,400 man-hours. Later, the calculations were made with the aid of punch-card equipment using electronic calculators capable of multiplying and dividing two 10-digit numbers at the rate of 6,000 per hour. Three people using this equipment could complete a single table in 360 man-hours and 240 machine-hours. Although the actual time required was greater than before, the number of man-hours was considerably less and the cost of preparation was correspondingly reduced. Recently, a program has been developed to carry out the computations on SEAC (National Bureau of Standards Eastern Automatic Computer). With the help of SEAC, only 20 hours will be required to complete a Loran project, and at a further reduction in the cost of the computation.

Loran has proved to be one of the most reliable means for navigating far out at sea or in the air, because low-frequency radio waves are used to carry the navigational information. Transmission is effective at distances up to 700 nautical miles during the day and 1,400 nautical miles at night. The transmitter sites are usually located near the sea and air lanes.

Navigation with Loran involves a determination of position with information derived from the time intervals between the signals of two or more pairs of transmitting stations. In practice, a three-station net-

Pictorial representation of Loran navigation in operation. A ship or airplane receives Loran signals on receivers specially designed to read directly the time difference between the pulse signals from a pair of transmitters. One line of position of the vessel is determined from the Loran table corresponding to the indicated time difference. The receiver is then switched over to receive another pair of stations and indicates another position. Again, the Loran tables will yield a line of position, and by triangulation on the Loran Chart, the absolute position of the vessel is determined.

work—a master and two slave transmitters in combination—provides the necessary two pairs of stations. The low-frequency signals are transmitted as a series of timed pulses; the pulses from the slaves are spaced within the intervals between those from the master. At increasing distances from the immediate transmitter area, the time interval between slave and master pulse will vary depending on the relative positions of the vessel and the pair of stations. Special Loran receivers aboard the ship or aircraft are designed so that the time difference can be read directly. The Loran table for this particular frequency, pair of stations, and time of day will yield one line of position for the vessel corresponding to the indicated time difference. The Loran receiver is then switched over to the other pair of stations—the master and the second slave—and indicates another time difference. Again, the Loran tables will yield a line of position, and by triangulation on a Loran chart, the absolute position of the vessel is determined.

The Loran system of position finding makes use of the fact that the hyperbola is the locus of a point that moves so that the difference in the distance of the point from two other fixed points is constant. The Loran lines of position are then families of hyperbolic curves, and when the navigator reads a constant time difference, he is actually fixing his position on one member of the family.

The preparation of Loran tables consequently requires the determination of the points on the family of hyperbolas determined by a pair of fixed transmitting stations. If the earth were a plane surface, this would be a simple process and the coordinates could be obtained in a direct manner. However, the earth is an oblate spheroid, and there are no simple mathematical formulas expressing the fact that a given curve on a spheroid is a hyperbola. Consequently, the problem must be approached in an indirect manner. One must compute a grid of time differences for certain prescribed latitudes and longitudes. From this grid it is possible to determine the required set of hyperbolas by the process of inverse interpolation (obtaining the argument from a given value in the body of the table).

The mathematical formulas giving the distance from the fixed transmitting stations are of considerable complexity. These formulas have been subjected to careful analysis to adapt them successively for calculation with desk calculators, punch-card equipment, and SEAC. Extensive auxiliary tables have been prepared to permit greater efficiency and speed in carrying out computations. These calculations required a high order of precision because the final computed results had to be entirely free of error. For example, below-optimum receiving conditions caused by adverse weather, coupled with a small error in the tables, could result in dangerously incorrect position plotting.

During the daytime Loran usefulness is limited to a range of 700 nautical miles in which signals may be received directly from the transmitters. These direct signals are known as ground waves to distinguish them from the sky-wave signals that are received at night, and sometimes during the day, after reflection from the ionosphere, a dense layer of ionized particles some 50 to 300 kilometers above the surface of the earth. The reception of these sky waves at night increases the useful range of Loran to 1,400 nautical miles. Since sky-wave signals take longer to reach the receivers than ground waves, included with each Loran table is a set of sky-wave corrections, which must be applied to compensate for the difference between the sky-wave and ground-wave paths. Sometimes sky waves are received that have been reflected more than once from the ionosphere; however, these cannot be used reliably for navigation purposes.

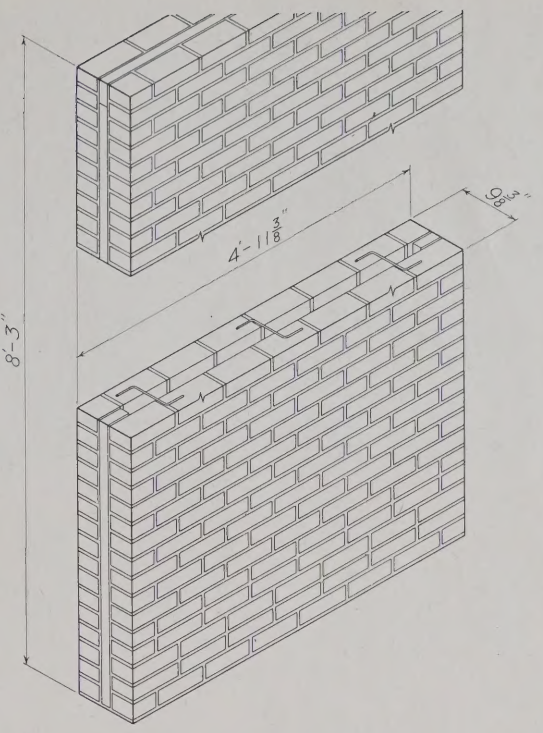
Insulating Effect of Cavity-Wall Masonry Constructions

IN RECENT years interest has increased in the advantages offered by cavity-wall masonry construction for buildings. Such a wall consists of an outer (facing) leaf, or wythe, of masonry separated from the interior backing wythe by a continuous air space 2 to 3 inches wide; the two wythes are generally bound together by cross ties of metal set in the wall as it is built. In order to determine the insulating value of the cavity wall compared to that of a solid wall, and to ascertain to what degree the ventilation of the wall with outdoor air might affect its insulating value, a number of heat transfer investigations have been made by the NBS Building Technology Division under the direction of Henry E. Robinson.

A major advantage of cavity-wall construction is provided by the air space, which prevents penetration to the inner face of rain or water that may leak through joints and minute cracks in the outer face. In addition, the air space breaks the continuity of the masonry, which has relatively low resistance to heat flow, and adds considerably to the thermal insulating value of the wall.

Water penetrating the outer wythe of a cavity wall seeps or trickles down its inner face and, by means of flashings set in the wall during construction, is diverted outward through weep-holes or occasional open vertical joints between bricks in the outer face. Such flashings and weep-holes are provided at the bottom of the cavity above grade and over windows and other openings through the wall. The weep-holes constitute openings into the cavity at different levels through which outdoor air can circulate; furthermore, there may be other fortuitous openings in the outer or inner wythes, or at the top, which also may permit or promote air circulation through the cavity.

Schematic drawing of a typical cavity brick wall investigated by the Bureau to determine the insulating effect of such construction as compared to a solid wall.



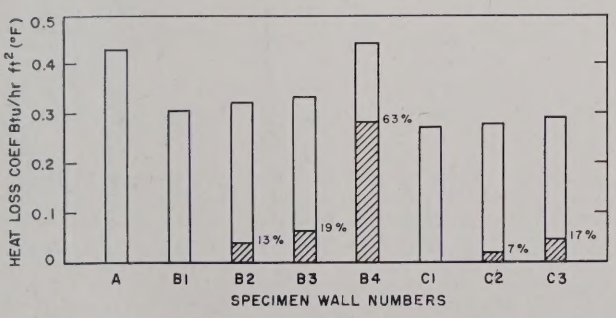
The heat-transfer measurements were made in the NBS vertical guarded hot-box heat-transfer apparatus on three different specimen walls 8 feet high and 5 feet wide. In this apparatus, one face of the wall is exposed to air at about 70° F, and the other face to air at about 0° F. By means of special equipment on the warm side, the heat flow through a centrally located and known area of the wall is determined. The temperatures of the air and wall surfaces are observed, thus enabling calculation of the heat-transfer coefficients of the wall.

Wall specimen A, the 8⅛-inch solid wall used for comparative data, was constructed of 8.1- by 3.6- by 2.3-inch clay bricks made from medium-strength soft mud, laid in common American bond with cement-lime mortar, without finish on either face. There were alternately five stretcher courses and one header course.

Wall specimen B, tested in various modifications designated as *B1*, *B2*, *B3*, and *B4*, was a brick cavity wall 9⅜ inches thick, with the brick facing and backing laid in stretcher courses and separated by an air space 2.1 inches wide. The wythes were connected by ¼-inch diameter, Z-shaped steel wall ties spaced about 22 inches apart at every sixth course. The cavity was sealed at the bottom, sides, and top leaving an effective cavity width of 4.2 feet. The brick and mortar were the same as those used for specimen *A*; there was no finish on either face. During construction, three bricks were omitted from the outside wythe at the third course, and three at the thirty-second course, leaving three openings into the cavity at the top and at the bottom of the wall spaced 86 inches apart vertically.

For the test of specimen *B1*, the openings were sealed completely with bricks and sponge rubber; in tests of specimens *B2*, *B3*, and *B4*, each opening was only partially closed, yielding aggregate openings of 4.2, 7.2, and 89.0 square inches area, respectively. These corresponded to ventilating openings of 1.0, 1.7, and 21.0 square inches area per linear foot of cavity length at the top and bottom of the wall. During the tests these openings permitted natural ventilation of the cavity, with the cold air bathing the cold side of the wall.

Wall specimen *C* was a cavity wall 9¾ inches thick with brick facing, structural clay-tile backing, a 2¼-inch cavity, and steel wall ties spaced about 24 inches apart at every sixth course of brick. The 3.8- by 5.0- by 11.5-inch structural clay-tile, each with four cells 1.07 by 1.73 by 11.95 inches in dimensions, were placed with the 5.0-inch dimension vertical. The edges of the cavity were sealed at the bottom, sides, and top of the wall; no finish was applied to either face. Three modifications of wall specimen *C* were tested, namely: *C1*, with the cavity completely sealed; *C2*, with small openings between bricks aggregating 0.9 square inches per linear foot of cavity at the top and at the bottom; and *C3*, with similar openings aggregating 2.5 square inches per linear foot of cavity. The openings were spaced 81 inches apart, vertically.



The results of the tests are shown in the bar chart and table. The heat-loss coefficients indicated by the bar heights are the observed thermal transmittances, expressing the number of Btu per hour flowing through 1 square foot of the warm face of the wall for 1 deg F difference of temperature of the air on the two sides of the wall. When the air was circulated gently on both sides of the wall during the tests, the average surface film conductances were approximately 2.0 Btu/hr ft² (°F) on the warm side and 1.6 on the cold side. The cross-hatched fractions of the bars for specimens *B2*, *B3*, *B4* and *C2*, *C3*, in all of which ventilation occurred, indicate the estimated percentage of the heat entering the cavity from the warm side that was carried out by the ventilating air. It is estimated that the rates of ventilation in the cavity were approximately 0.4, 0.6, and 3.1 cubic feet per minute for each linear foot of cavity length for specimens *B2*, *B3*, and *B4*, respectively, and 0.2 and 0.6 for specimens *C2* and *C3*.

Heat loss coefficients of cavity walls

Wall type and number	Openings for cavity ventilation	Heat loss coefficient	Estimated heat carried out by ventilating air
	in.²/linear ft.	*Btu/hr. ft.²* (° *F.*)	%
Solid brick, *A*	0.0	0.44	
Brick cavity, *B1*	.0	.31	0
Brick cavity, *B2*	1.0	.33	13
Brick cavity, *B3*	1.7	.34	19
Brick cavity, *B4*	21.0	.45	63
Brick-tile cavity, *C1*	0.0	.27	0
Brick-tile cavity, *C2*	.9	.28	7
Brick-tile cavity, *C3*	2.5	.30	17

Under the test conditions, the heat-loss coefficient of the sealed brick cavity wall was only 70 percent of that of the solid wall using the same amount of material. The small amounts of ventilation that took place in walls *B2* and *B3* increased the cavity-wall heat loss only moderately to respective values of 75 and 77 percent of that of the solid wall. The openings in the cold face of wall *B4* were much larger than might be expected in practice, but even under these conditions the cavity wall was approximately equal to the solid wall in insulating effect. A solid counterpart of the brick-tile cavity wall was not tested, but it is estimated that for such a solid construction the heat loss coefficient would be about 0.38 BTU/hr ft² (°F). On this basis, the heat loss coefficients for the brick-tile cavity wall were approximately 73, 75, and 78 percent of that of the corresponding solid wall for specimens *C1*, *C2*, and *C3*, respectively. In practice the weep-hole openings needed to drain water from a cavity wall would probably not aggregate an area greater than 1 square inch per linear foot of cavity; consequently nearly all of the insulating effect of a sealed cavity wall of similar height may be realized under ordinary conditions without high winds.

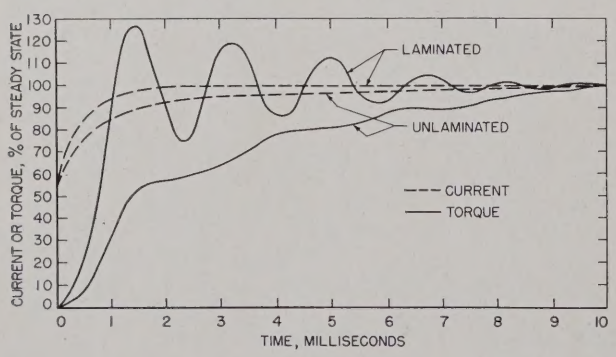
In considering these results, it must be recognized that greater vertical height between openings into the cavity would increase the ventilation rate, although probably not to a serious degree for cavities not more than 2 or 3 stories high.

For further technical details see NBS Buildings Materials and Structures Report, BMS 82, Water permeability of walls built of masonry units. *These reports are available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for 25 cents.*

Response Time of the NBS Magnetic Fluid Clutch

A RECENT study at the National Bureau of Standards indicates that response time of the NBS Magnetic Fluid Clutch can be reduced to the order of 1.5 milliseconds for 63 percent of maximum torque. The study, made by W. A. Notz of the NBS electronic computers laboratory to learn how to maximize response speed of the new clutch, provides new understanding of the limiting factors involved.

The NBS Magnetic Fluid Clutch was invented by Jacob Rabinow of NBS in connection with the active NBS electronic-digital-computer program, primarily to meet the need for a fast-acting start-stop computer input mechanism. The distinctive feature of the clutch is the use of a magnetic fluid, consisting of a mixture of iron particles and oil, to couple the rotating input member to the output member. When a magnetic field is applied to the fluid, the mixture virtually solidifies, binding the input and output members together. If other factors are kept constant, the torque developed by a clutch of this type appears to be proportional to the magnetic flux, which is in turn essentially proportional to the exciting current.

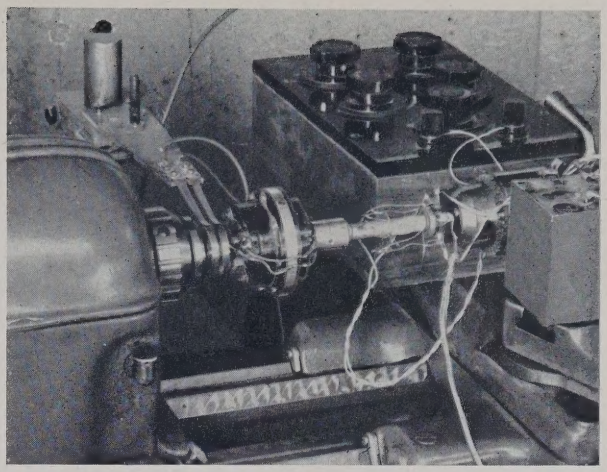


Curves showing torque-time and current-time relations for two models of the NBS Magnetic Fluid Clutch, one model having a laminated magnetic circuit and the other unlaminated. The oscillation in output torque observed in the laminated clutch could be practically eliminated by using a more rigid output shaft; this would not appreciably increase the inertia or the response time.

The NBS study makes it clear that the clutch's magnetic circuit should be laminated for fastest response; otherwise current, flux, and torque will be slow to build up because of eddy currents. Analysis shows that the torque-to-inertia ratio will be maximized, favoring fast response, if the inertia of the clutch output disk equals three times the load inertia. The ultimate natural frequency—and the response speed—will generally be determined by the iron-oil mixture and the gap width in the magnetic circuits.

Two clutch models were studied in the NBS response-time investigation, both of the type having a thin, flat output disk attached to the output shaft—a design that minimizes output-system inertia. The two clutches were almost identical in construction, except that one was made with a laminated magnetic circuit to reduce eddy currents, whereas the other was of unlaminated construction and had an output shaft of larger diameter.

Response time was determined by fastening a strain gage to the output shaft and connecting the electrical



Test set-up for recent National Bureau of Standards investigation of response time of the NBS Magnetic Fluid Clutch. The clutch model under study was mounted in a lathe, with a strain gage connected to the output shaft to measure the output torque.

output of the strain gage to the vertical input of a cathode-ray oscilloscope. By starting the horizontal sweep of the oscilloscope simultaneously with application of the clutch excitation voltage, a trace of output torque versus time was obtained. Besides these torque-time determinations, some displacement-versus-time tests were made, and also some steady-state measurements of torque versus current.

Response time of the laminated clutch was found to be limited only mechanically, whereas response of the unlaminated model was limited by eddy currents—because of these, magnetizing current and output torque were slow to build up. Output torque of the laminated clutch oscillated considerably for several milliseconds after application of voltage. Since the output system of the laminated clutch could be stiffened by using a larger-diameter output shaft, and since the elasticity of the strain-gage shaft would be eliminated in practical applications, the amplitude and period of oscillation of the disk-and-shaft output system could be made negligibly small in practice. Rise in output torque would then be approximately exponential.

Assuming ideal mechanical resistance and stiffness, response speed can be maximized by maximizing the torque-to-inertia ratio. It can be shown that this calls both for the above-mentioned 3-to-1 ratio of disk inertia to load inertia, and for driving the magnetic circuit to saturation as rapidly as possible.

The clutches studied gave torques of the order of 7.5 pound-inches with 250 ampere-turns of magnetization. Indications are, though, that the number of ampere-turns could be quadrupled without either fusing the coils or saturating the magnetic circuit. This would give a maximum torque of 30 pound-inches. To drive the clutch to this value with a time-constant of 1.5 milliseconds, 1.0 ampere would have to be supplied to the coils from an 800-volt source in series with an 800-ohm resistor, or from an equivalent circuit.

In a practical installation, a high-voltage pulse would be used to supply, for only a few milliseconds, the large amount of power (dissipated in the external resistor) needed to get the load up to speed rapidly; the power would then be reduced to give a torque just sufficient to overcome the friction of the load. For fast stopping and reversing, as well as starting, two of the NBS clutches can be connected so as to apply torque in either direction when the proper clutch is energized. The NBS study indicates that when the current supplied to the clutch is cut off, the torque decreases to the deenergized value at least as fast as it built up; a load can probably be stopped about as quickly as it can be brought up to speed.

More remains to be learned about some aspects of response time of the NBS Magnetic Fluid Clutch. It is hoped that future work will center on the transient transfer of power through the iron-oil mixture. Such work should include analysis of effects on response time of (1) the fluid gap width, (2) the ratio of iron to oil, (3) the iron-particle size, and (4) the viscosity and surface tension of the oil.

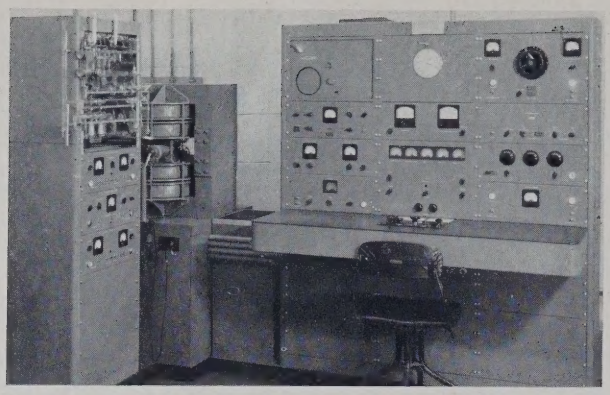
For further technical details see Magnetic fluid clutch, *NBS Tech. News Bull.* **32,** *54 (May 1498)*; *also* The magnetic fluid clutch, *by Jacob Rabinow, Trans. AIEE* **67,** *1308 (1948)*; New uses for magnetic fluids, *NBS Tech. News Bull.* **33,** *74 (June 1949)*; *and* Further Development of the NBS Magnetic Fluid Clutch, *NBS Tech, News Bull.* **34,** *169 (Dec 1950)*.

Change in X-Ray Protection Handbook Announced

Recent experimental work by the Radiation Laboratory of the National Bureau of Standards has shown that certain requirements governing the safe use of medical X-rays can be somewhat relaxed. Subcommittee 3 of the National Committee on Radiation Protection has therefore voted that the recommendation published in Section 7.1d of National Bureau of Standards in Handbook 41, *Medical X-ray protection up to two million volts,* now reading "The aluminum equivalent of the table top shall not be more than 0.5 millimeter at 80 kilovolts when a Bucky is used under the table top," be changed to "The aluminum equivalent of the table top shall not be more than 1.0 mm when measured at 80 kilovolts without a patient or phantom."

This change was announced by H. O. Wyckoff, chairman of Subcommittee 3 of the National Committee on Radiation Protection, which is under the sponsorship of the National Bureau of Standards in cooperation with the leading radiological organizations. NBS Handbook 41 is one of several X-ray protection codes prepared by the Committee and published by the National Bureau of Standards.

Source of Defect-P
Porcelain-E



Gas-analysis mass spectrometer used at NBS to determine the amount of heavy hydrogen in gas samples collected from coated-steel specimens after firing. Samples are ionized and the ions accelerated in a magnetic field. The amount by which a charged particle is deflected as it moves through the magnetic field depends upon its mass. Gas samples, including those containing different isotopes, are readily analyzed by application of this principle.

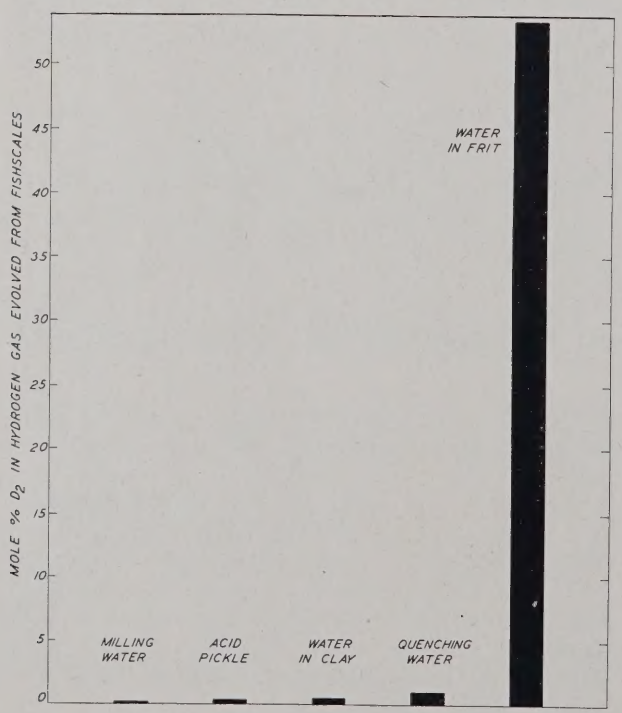
HYDROGEN gas evolved during and after the firing operation has for some time been recognized as a cause of defects in porcelain-enameled and ceramic-coated steel. At high temperatures the gas may cause blistering during the firing, or "reboil" (the blistering of a vitreous coating when reheated after the first firing). At ordinary temperatures, if the gas is trapped in the steel during rapid cooling after firing and later escapes, "fishscaling" may occur; gas pressure opens scale-like fissures, and in some cases literally blows off flakes of the coating. Until now, the relative importance of the different possible sources of the hydrogen causing the defects has been largely a matter of conjecture. Uncertainty as to the origin of the gas has made the problem difficult to cope with effectively.

A recent NBS investigation, using heavy hydrogen as a tracer, now indicates that water present in the frit (glass) used in the coating is largely to blame for hydrogen-produced defects. Moreover, confirming experiments demonstrate the feasibility of producing a coating free from hydrogen defects, by using a water-free frit. Results of the new study, which was undertaken for the National Advisory Committee for Aeronautics by D. G. Moore, Mary A. Mason, and W. N. Harrison of the NBS staff, should enable manufacturers to produce better porcelain-enameled steel.

At the beginning of the investigation it was considered that defect-producing hydrogen could conceivably originate in any of a number of ways. First, there is the acid-pickling operation used to clean the steel; some of the hydrogen formed by the acid-steel reaction might be occluded by the metal. Second, any water present during the firing operation could react with the iron in the steel to form iron oxide and hydrogen. Possible sources of water during firing appeared to be (a) water vapor in the furnace; (b) the water used for milling and suspending the enamel slip; (c) the water chemically combined in the clay used for suspending the slip; or (d) dissolved water in the frit used in the enamel.

The NBS investigation sought to establish the relative importance of these five possible sources. The problem was attacked by substituting heavy hydrogen (deuterium), in the form of heavy water, for ordinary water at each of these five possible hydrogen-producing points in the coating process. Heavy hydrogen and ordinary hydrogen have almost identical chemical properties and very similar physical properties. But because they differ in mass, the two isotopes can be readily separated with the mass spectrometer.

In a series of experiments the heavy-hydrogen substitution was made at one point at a time. Different techniques were required to effect the desired substitution at the different points. In the case of the dis-



When the NBS recently investigated sources of defect-producing hydrogen in porcelain-enameled steel, dissolved water in the frit (glass) used in the coating was found to be much the most important source. Heavy hydrogen (deuterium) introduced at different points in the coating process served as a tracer in the NBS study. The heights of the bars indicate the relative importance of the various possible sources of hydrogen investigated.

ducing Hydrogen in ameled Steel

solved water in the frit, the substitution involved heating normally smelted frit under reduced pressure to remove the ordinary water, then heating with heavy water under increased pressure.

In each group of experiments samples of two steels were coated: 18-gage enameling iron and a 10-gage low-carbon steel that had given considerable trouble from delayed fishscaling in one enameling plant—a coating showing poor adherence was used so that defects would be accentuated. The gases given off by each enameled-steel specimen after firing were collected for analysis. This was done by quickly placing the fired specimen in a glass collection cell and heating to 338° F at reduced pressure for 17 hours. The cell was then allowed to cool and the pressure noted.

The ratio of heavy hydrogen to total hydrogen in the collection cell, as shown by the mass spectrometer, varied widely with the particular source under study (see table). When the frit had heavy water substituted for ordinary water, heavy hydrogen constituted about 53 mole percent of total hydrogen recovered. In contrast, the corresponding figure was only about 1 percent when what proved to be the next most important source of hydrogen—the quenching water—was under study. The acid-pickling process, the milling water, the chemically combined water in the clay, and the quenching water thus all proved to be minor sources of defect-producing hydrogen under the experimental conditions. The 18-gage enameling iron and the 10-gage low-carbon steel behaved similarly in these experiments.

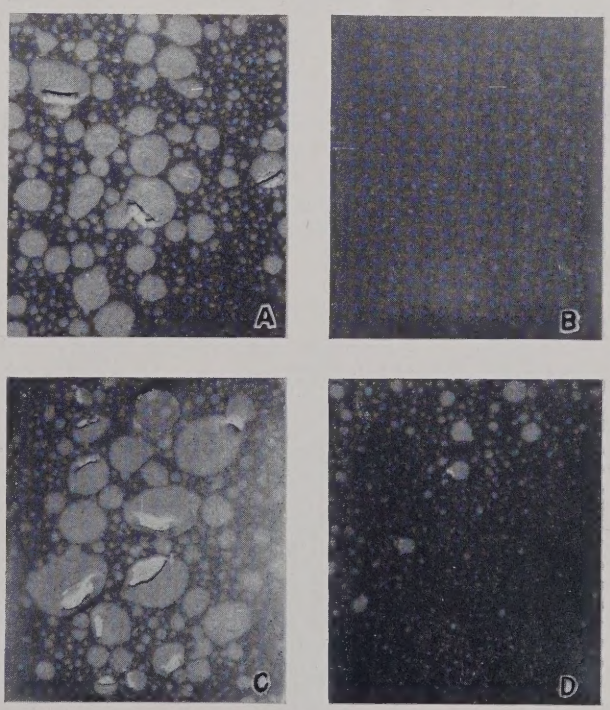
The finding with the heavy hydrogen tracer—that dissolved water in the frit was the principle source of defect-producing hydrogen—was confirmed by supplemental experiments. In these, steel specimens coated with normally prepared frit were compared for defects with specimens coated with frit from which dissolved water had been largely or entirely removed. In each case the frit was applied without the use of the customary clay, water, and other mill additions. This was done by dry-grinding the frit, suspending it in a water-free organic solvent, and spraying it on. After air-drying, the specimens were fired for the normal time.

Two methods of preparing water-free frit were used in these experiments: drying normally prepared frit by vacuum melting, and preparing frit from dried raw materials. Neither lifting nor fishscaling occurred with the vacuum-melted frit, although both these defects were pronounced with the normally prepared frit. Other experiments with reboiling gave confirmatory results. Attempts to prepare defect-free frit from raw materials from which most of the water had been removed were somewhat less successful; some defects developed, though not nearly as many as with the normally prepared frit.

Volume of hydrogen gas collected, mole percent of deuterium in the hydrogen, and relative importance of the investigated sources of defect-producing hydrogen in steel

Source investigated	Steel base	Volume of hydrogen collected [a]	D_2 in hydrogen	Relative importance of source
		cm³/100 g steel	*mole percent*	
Pickling acid	A	0.27	0.1	4
	B		.5	
Milling water	A	.24	.1	5
	B	.32	.1	
Water in clay	A	.25	.2	3
	B	.28	.8	
Quenching water	A	.80	.5	2
	B	.20	1.5	
Dissolved water in frit	A	.56	53.5	1
	B	.44	52.9	

[a] Computed from change in pressure in collection cell after 17 hours at 338° F and from the hydrogen content of collected gas. Values are for gas at standard conditions.

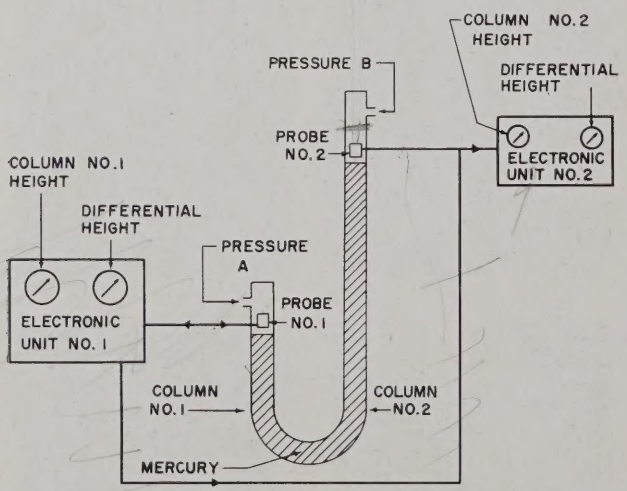


Specimens in NBS investigation of hydrogen-produced defects in porcelain-enameled steel. Light areas are separations at the interface caused by hydrogen evolution from metal. A: Enameling iron coated with a normally prepared ground coat frit containing no adherence oxides. B: The same frit after vacuum-melting to remove dissolved water. C: Vacuum-melted frit subsequently autoclaved with heavy water and then remelted. D: The same frit as A but prepared from dehydrated raw materials and melted in an electric rather than a gas-fired furnace. (Actual size.)

Electronic Sensing of Mercury-Column Height

One of the two electronic units used in the NBS mercury-column height-sensing system. The meter on the left indicates the distance of mercury column No. 1 from its associated probe, while the one on the right shows when the probe-to-mercury distance is identical for columns No. 1 and No. 2. The other electronic unit, associated with mercury column No. 2, gives similar information for its respective column.

DIFFERENCES in height—and thus in pressure—between the two mercury columns of a mercury manometer are being determined with high precision by an application of the National Bureau of Standards electronic micrometer principle.[1] The new height-sensing technique [2] was developed by M. L. Greenough and W. E. Williams of the NBS electronic instrumentation laboratory, to meet special pressure-measurement requirements arising at the Bureau. Based on the use of high-frequency mutual-inductance probes, the method is sensitive to height changes of as little as 0.0005 inch. It also has the advantage of not requiring direct visual observation of the mercury surfaces; the mercury columns need not have transparent windows, and readings can be made at a distance. Since no float or electrical contact is required, disturbance of the mercury surface is minimized.



Simplified diagram of the new NBS method. Mounted above each mercury surface is a high-frequency mutual-inductance probe. When radio-frequency current is supplied to the primary of the probe, the secondary voltage varies with the distance of the mercury. This current-voltage relation gives a very sensitive indication of changes in mercury height.

Above the mercury surface in each column is mounted a mutual-inductance probe consisting of a primary and a secondary coil. When the primary coil is supplied with constant radio-frequency current, the voltage induced in the secondary varies with the mutual inductance, or coupling between the two coils. The mutual inductance, in turn, varies with the proximity of the mercury surface; the closer the mercury surface is to the probe, the greater is its shielding effect, and the less the output voltage. The output voltage thus becomes an index of probe-to-mercury distance and can be used to indicate this distance with high precision.

In the present NBS arrangement the electronic circuitry, except for the two probes, is contained in two small cabinets, one for each mercury column. Each cabinet is connected electrically to its associated probe and to the other cabinet. One zero-center microammeter on each cabinet is calibrated to indicate variations in the height-difference of the two mercury columns. When these differential-height meters read zero, the probe-to-mercury distances in the two columns are identical. The difference in the mercury-surface heights is then equal to the difference in the probe heights, which is known or determinable. With this form of null indication, the mercury columns may be reset accurately to the same differential height, assuring reproducible pressures. Since the differential-height meters have a measurement range of only about 0.04 inch, individual-height meters with a range of 0.3

inch are provided to facilitate preliminary adjustment of the mercury columns.

The primaries of the two probes are excited by a 480-kilocycle amplitude-regulated oscillator. A vibrating relay compares the outputs of the pickup secondaries by switching first to one and then to the other. The difference in the outputs is amplified, rectified, and applied to the differential-height meters.

[1] Shielding principle provides electronic micrometer, *NBS Tech. News Bul.* **31,** *37 (Apr. 1947). For other applications of the principle see,* An electronic circuit for measuring the displacement of pressure-sensitive diaphragms, *M. L. Greenough and W. E. Williams, J. Research NBS* **46,** *5 (Jan. 1950) RP2168, summarized as* Diaphragm-type micromanometer with electronic pickup, *NBS Tech. News Bull.* **34,** *137 (Oct. 1950). See also* Oil-film thickness indicators for sleeve-type bearings, *NBS Tech. News Bull,* **35,** *120 (Aug. 1951.)*

[2] *For further details of the new height-sensing technique see,* Sensitive mercury-level detecting unit for manometers, *W. E. Williams, J. Research NBS* **48** *(Jan. 1952) RP2283.*

Resistance of Floor Coverings to Grease, Oils, and Selected Reagents

THE EFFECTS of grease, oils, alkalies, acids, and bleaches on 40 floor coverings from 17 different manufacturers have been investigated by P. A. Sigler and T. H. Boone of the National Bureau of Standards. Conducted at the request of the Office of the Chief of Engineers, Department of the Army, the tests were made on coverings ranging from such general types as vinyl, rubber, linoleum, asphalt, and printed enamel to several proprietary materials. The reagents to which these coverings were exposed included beef tallow, kerosine, cottonseed oil, lubricating oil, solutions of soap, sodium carbonate, trisodium phosphate, sodium hydroxide, acetic acid, sulfuric acid, and hydrogen peroxide.

As a standard testing technique for evaluating these properties was not available, a technique was devised that essentially measured the depth of a scratch caused by a "mechanical fingernail" after exposure of the material to the reagent for 24 hours. While this method has not as yet been thoroughly correlated with the scratch resistance of floor coverings in service, it has since been included in interim Federal Specifications for asphalt tile, No. SS–T–307 (GSA-FSS) of October 1, 1951.

Method

In detail, the method involved the use of a Taber Abraser equipped with an attachment for measuring shear hardness to determine the softening effect of the reagents on the various floor coverings. The coverings were prepared for testing by cementing the surface of a 2- by 4-inch specimen on one end of a hollow sheet-metal cylinder, 1½ inches in diameter. Ten milliliters of test reagent was poured into the cylinders, covered to retard evaporation, and allowed to stand for 24 hours. After the reagent and cylinder were removed from the specimen, the exposed surface was blotted lightly and examined visually for defects.

The specimen was then placed on the turntable of the Taber Abraser and a 1-inch scratch made by means of a sharp-edged tool on a pivoted beam under a load of 500 grams. The tool was curved so that the scratch width was reasonably proportional to its depth. A scratch width of over 150 mils was considered to indicate a softening effect; a scratch width of between 100 and 150 mils, a slight softening effect; and a width below 100 mils, no softening effect.

Results

Of the various floor coverings tested, the vinyl plastics were, in general, most resistant to grease and oils. With a few exceptions, they also showed fair to good resistance to alkalies, while a number of the plastic floor coverings were adversely affected by dilute acids.

The regular asphalt tiles showed very poor resistance to most of the oils and only fair resistance to beef

The Taber Abraser was used at NBS to investigate the resistance of 40 floor coverings to grease, oils, and selected reagents. The Abraser, equipped with a special pivoted beam mounted with a sharp-edged tool under a 500-gram load, determined the softening effect of the reagents on the floor coverings. Rotating the turntable produced a scratch 1 inch long in the specimen; the width of the scratch gave a measure of the resistance of the various coverings to different reagents.

tallow. Some of the so-called "grease-resistant" asphalt tiles were not outstanding as regards grease and oil resistance, and most showed poor resistance to dilute acids.

All of the linoleums were materially affected by alkaline cleaning solutions and were partially disintegrated by a 1-percent solution of sodium hydroxide. They provided poor resistance to acids and hydrogen peroxide, and with the exception of brown battleship linoleum, were appreciably softened by kerosine. Several were also slightly softened by beef tallow.

None of the rubber tiles withstood the effects of kerosine, but all were resistant to beef tallow. Their resistance to dilute acids and alkalies varied from good to poor.

In general, the enamel-print felt-base floorings were damaged by alkaline cleaners, dilute acids, and kerosine. The mastic (bituminous) felt-backed floor coverings provided poor resistance to kerosine and were slightly softened by beef tallow. A proprietary floor covering having a resin-composition wearing surface showed fair to good resistance to the various oils and reagents with the exceptions of kerosine and dilute acids. A cork-composition flooring gave fair to good resistance for the various oils and reagents, with the exception of sodium hydroxide.

From an over-all viewpoint, the vinyl plastics tested possessed the best properties for use in locations likely to be subjected to frequent exposure to grease, oils, and alkalies. However, at least one of the vinyl plastic samples showed a poor resistance to five of the ten reagents, and it is questionable if vinyl plastic floor coverings can be satisfactorily installed on concrete subfloors that are in direct contact with the ground unless the concrete floor has been thoroughly membrane waterproofed. Asphalt tile, on the other hand, can be successfully laid on a concrete floor that is subject to damp conditions.

None of the reagents was highly destructive to all of the samples. At least two of the materials showed excellent resistance to each reagent. Although materials of a given type tended to be resistant to the same reagents, the differences between the resistance of individual samples of a given material was large enough to indicate the desirability of testing samples of floor coverings where severe conditions are anticipated.

Resistance of floor coverings to grease, oils, and reagents [a]

Material	Number of samples	Kerosine	Cottonseed oil	Lubricating oil	Beef tallow	Cleaner: 0.5% soap, 0.2% Na_2CO_3	Na_3PO_4 1%	NaOH 1%	Acetic acid 5%	H_2SO_4 5%	H_2O_2 3%
Vinyl plastic, flexible	5	1-E	4-E	4-E	4-E	2-E	3-E	2-E	1-E	2-E	2-E
		4-G	1-G	1-G	1-G	1-G	1-F	1-G	1-G	1-G	1-G
						1-F	1-P	2-P	2-F	2-P	1-F
						1-P			1-P		1-P
Vinyl plastic, felt-backed	3	3-E	1-E	3-E	3-E	1-E	2-E	3-E	1-E	1-E	2-E
			2-G			2-G	1-G		2-F	2-G	1-G
Vinyl plastic, cork-backed	2	1-E	2-E	2-E	1-E	2-E	1-E	1-E	2-E	2-E	2-E
		1-G			1-G		1-F	1-F			
Vinyl plastic, semiflexible	3	2-G	2-E	3-E	1-E	3-G	2-E	1-E	1-G	2-G	1-E
		1-F	1-G		2-G		1-G	1-G	1-F	1-F	2-G
								1-F	1-P		
Asphalt tile, grease resistant	4	1-E	1-E	2-E	1-E	3-G	1-E	2-E	1-G	1-E	4-G
		1-F	2-G	2-G	3-G	1-P	2-G	1-G	3-P	3-P	
		2-P	1-P				1-P	1-F			
Asphalt tile, regular	7	7-P	7-P	2-E	1-G	5-G	6-E	3-E	4-G	1-G	3-E
				1-G	6-F	2-F	1-G	4-G	1-F	3-F	4-G
				1-F					2-P	3-P	
				3-P							
Linoleum, felt-backed	4	4-P	2-E	2-E	1-E	2-F	4-P	4-P	4-P	1-E	1-F
			1-G	1-G	3-F	2-P				1-F	3-P
			1-P	1-P						2-P	
Linoleum, burlap-backed	2	2-G	2-E	2-E	2-E	2-F	1-F	2-P	1-F	1-E	2-F
							1-P		1-P	1-G	
Rubber	3	1-F	1-E	2-E	3-E	1-E	2-E	1-E	1-G	1-F	1-E
		2-P	1-F	1-F		1-G	1-F	2-P	2-F	2-P	1-G
			1-P			1-F					1-F
Enamel print, felt-backed	3	1-G	1-E	1-E	2-G	1-F	3-P	3-P	3-P	1-G	2-F
		2-P	2-G	2-G	1-P	2-P				2-P	1-P
Mastic composition, felt-backed	2	2-P	1-E	1-E	2-F	2-G	1-G	2-P	2-F	2-G	1-E
			1-G	1-G			1-P				1-G
Resin composition felt-backed	1	P	G	E	E	F	E	F	P	P	G
Cork composition	1	G	E	E	E	G	G	P	F	E	G

[a] Rated as: E, excellent; G, good; F, fair; P, poor.

NBS Symposia and Society Meetings

Resistance Strain Gages

THE NBS Symposium on Resistance Strain Gages, held at the National Bureau of Standards on November 8 and 9 in cooperation with the Office of Naval Research, brought together about 300 engineers and physicists, representing most of the engineering industries and Government and university laboratories. The large attendance at the symposium, the eleventh of a series marking the NBS semicentennial year, is evidence of the revolutionary impact that the resistance-wire strain gage has had on mechanical testing in this country during the past decade. It was only 10 years ago that a practical method was found for measuring the internal strain of a structure by utilizing the change in electrical resistance of fine wire bonded to it. The symposium was under the joint chairmanship of Dr. Walter Ramberg and W. R. Campbell of the NBS Mechanics Division.

Three of the 11 papers presented at the symposium dealt with the properties of the fine wire in the resistance-wire strain gage itself. Particular attention was given to the change in resistance of the wire for strains beyond the elastic range of the wire material.

Seven of the papers were concerned with applications of the wire strain gage in industry and in the laboratory. A. C. Ruge (Ruge-deForest, Inc.) and A. L. Thurston (Cox & Stevens Aircraft Corp.) described several applications of the bonded-wire strain gage, in which the wire is cemented to the metal. These included industrial uses as diverse as the control of drilling pressure in an oil well; the measurement of torque transmitted by propeller shafts; control of rolling-mill pressure in a steel mill; the weighing of aircraft; the weighing of cattle on the hoof; and the checking of trailer trucks for over-loading as the truck speeds along the highway over an instrumented section of concrete.

Present practice in the application of wire strain gages in Europe was described by Dr. R. G. Boiten of Holland and Dr. G. V. A. Gustafson of Sweden. The application of the bonded-wire strain gage in the construction of dynamometers, to calibrate testing machines of the largest capacity for the first time over their full range, was described by D. R. Tate (NBS). Their application to measure strain inside concrete during freezing and thawing tests and to measure strain at the surface of concrete specimens under impact load was reported by R. C. Valore, Jr. and David Watstein (NBS). The development of the unbonded wire strain gage as a basic element for measuring force, pressure, displacement, and acceleration, as well as strain, was covered by Louis Statham (Statham Laboratories, Inc.).

The technical sessions were brought to a close with a paper by W. R. Campbell (NBS), who discussed the change in electrical resistance with strain imposed on evaporated films of nine different elements. Among these, carbon films showed the greatest promise because of their extremely high output, coupled with approximate linearity for strains up to 15 percent. The symposium thus ended by calling attention to the first resistance strain gage to see widespread use. This was the assembly of carbon particles used in the telephone receiver as an electrical indicator of a mechanical quantity, sound pressure.

Electrodeposition

A SYMPOSIUM on Electrodeposition Researches in Progress, the last of 12 symposia marking the Semicentennial of the National Bureau of Standards, was held on December 4 to 6, 1951. Nearly 200 persons attended the sessions, at which reports were received from 22 industrial, educational, and governmental laboratories in the United States, England, France, and Holland. The symposium, sponsored by the NBS in cooperation with the Office of Naval Research, was under the chairmanship of William Blum, Chief of the NBS Electrodeposition Section.

George E. Gardam (Director of Research for the Gold, Silver and Jewelry Industries) opened the technical sessions with a report on English researches in progress. These include the electrodeposition of alloys of tin with zinc and of tin with nickel, chemical, polishing and electropolishing of metals, and the cause of porosity in electrodeposits. Jean Salauze (Société des Accummulateurs, France) described the principal electrodeposition studies in France on hard chromium plating, electropolishing, and anodic oxidation of aluminum. Studies now being conducted in Holland on electroforming were discussed by P. Baeyens (Philips Gloeilampenfabrieken). The principal NBS electrodeposition researches, reported by William Blum, include electrodeposition of unusual metals from nonaqueous solutions, electroforming, electropolishing, thickness measurements, and improvement of the surface properties of molybdenum.

At the second session, Charles L. Faust described the work at Battelle Memorial Institute on electroforming, and on deposition of alloys of chromium with iron and of zinc with tin and with manganese. A recently developed self-regulating chromium bath and pyrophosphate baths for depositing copper and zinc were reported by J. E. Stareck (United Chromium, Inc.). O. C. Ralston (U. S. Bureau of Mines) described methods for the electrolytic recovery of zinc, manganese, cobalt, and chromium. Wm. H. Colner (Armour Research Foundation) discussed the Founda-

tion's investigations of plating on titanium, silver plating of wave-guides, and deposition of magnetic nickel-cobalt alloys.

A color film, presented by George Jernstedt during the third session, showed the Westinghouse Electric Corporation's modern research laboratory for electrodeposition, in which studies on periodic reverse current plating are in progress. K. G. Compton and R. Ehrhart of the Bell Telephone Laboratories reported on the definition and control of a brass plating bath for producing deposits to secure adhesion of rubber to steel. The application of electroplated coatings in the construction of trimetal sleeve bearings used in aircraft and other high-duty engines were described by R. A. Schaefer (Cleveland Graphite Bronze Co.). The current research program of Enthone, Inc., as outlined by Walter R. Meyer, includes the study of conversion coatings on zinc, blackening of metals, chemical displacement coatings, oxide coatings, and methods of plating and of stripping coatings. M. R. Caldwell, L. B. Sperry, H. K. DeLong, and L. M. Morse described the joint research by the Doehler Jarvis Corp., the Dow Chemical Co., and the Chrysler Corp., on the protective value of plated coatings on die castings of zinc, aluminum, and magnesium. E. R. Bowerman stated that Sylvania Electric Products is studying methods of plating extremely fine wires and the deposition of tin-zinc alloys.

The final sessions of the symposium were devoted to several research projects now being conducted by the American Electroplaters' Society. Earl J. Serfass (Lehigh Univ.) is studying methods of determining impurities in plating solutions and plating wastes, while D. T. Ewing (Michigan State College) is investigating the effects of impurities in plating baths. The porosity and permeability of plated coatings is under study by N. Thon (Princeton Univ.) and F. Ogburn (NBS). Also at the NBS, A. Brenner and associates have just completed an extensive study of the physical properties of electrodeposited nickel. B. F. Dodge (Yale Univ.) is currently studying the disposal of plating room wastes, including cyanides and chromic acid. J. Kronsbein (Evansville College) reported on his studies of current and metal distribution in electrodeposition, while H. B. Linford (Columbia Univ.) described the methods being investigated for cleaning and preparing metals for plating.

Electron Physics

THE FIRST symposium devoted exclusively to the field of electron physics was held on November 5 to 7, 1951, at the Bureau as part of the NBS Semicentennial program. More than 100 physicists, representing the universities, Government research establishments, and industrial laboratories of nine nations, participated. The Symposium, sponsored by NBS in cooperation with the Office of Naval Research, was under the general chairmanship of Dr. L. Marton of the NBS electron physics laboratory. Forty-seven papers were presented, covering both the theoretical and experimental aspects of the subject.

Electron physics, for the purposes of this symposium, is interpreted to mean the physics of free electrons as distinguished from physical electronics, which is a study of bound electrons. The study of electron physics is divided into two broad classifications, or methods of attack, corresponding to the two dissimilar types of behavior demonstrated by the free electron: at times it behaves like a wave, at other times like a particle. The wave concept is employed in treating the interaction of electrons with matter, as in electron diffraction and the various types of electron scattering. It has long been realized that progress in this field can be made only by considering the electron as a DeBroglie wave packet and treating it by quantum mechanics. The particle concept has customarily been employed in the treatment of electron optics, which is concerned with the behavior of free electrons in electric and magnetic fields. Here the electron is considered as a charged particle obeying the laws of classical mechanics. A major contribution of electron optics was the development of the electron microscope, which has opened a new world to the biologist.

The 47 papers were given in seven sessions, two of which were devoted to electron scattering, four to electron optics, and one to experimental techniques. The first session, on theoretical electron optics, included discussions on electron lenses. A paper presented by W. Glaser (Vienna, Austria), on "The fundamental problems of theoretical electron optics", suggested that many basic electron-optical problems may be very effectively treated using a wave-mechanical approach, particularly where classical methods of geometrical optics fail because of fundamental differences between electron and light beams.

The second session was devoted to papers on experimental scattering, including the scattering of electrons in gases, electron diffraction, and the measurement of electron energies. Experimental electron scattering was reviewed by W. Bothe (Heidelberg, Germany) from the standpoint of nuclear scattering of positrons and electrons, electron-electron scattering, and positron-electron scattering.

Session three, on experimental techniques, brought together both the wave and particle classifications in discussions on electron microscopy and microanalysis. The evening session was concluded with a general discussion on experimental techniques used by many of the investigators attending the symposium.

Theory of scattering was the subject of the fourth session of the symposium from the standpoint of diffusion in media and the scattering of charged particles. H. Feshbach (MIT) presented a paper that included new and precise calculations of the scattering of electrons and positrons by point nuclei, as well as the theory of inelastic scattering with excitation of the target nucleus.

During the session on experimental electron optics (session five), results were discussed of investigations into cathode-ray tubes, electron-lens raster systems, and the effect of electron bombardment in evacuated systems. The following session was another devoted to the theory of electron optics. Papers were presented on electrostatic lenses, Magnetron theory, and shadow microscopy. Progress in diffraction microscopy from the theoretical standpoint was reviewed by D. Gabor (London, Eng.).

The final session included general discussion on image formation. Here, again, the many papers made use of the wave-particle approach to investigations involving magnetic lenses.

One significant trend was noted: for the first time a large percentage of the papers in electron optics were concerned with electron wave-optics. A concerted effort seems to be under way to bridge the gap between wave and particle classifications, or methods of attack, and thus to create a virtually new field for investigation.

Mass Spectroscopy

AS PART of its semicentennial, the National Bureau of Standards recently acted as host to a large group of physicists specializing in the field of mass spectroscopy. From September 6 to 8, 1951, participants from 11 nations, including 12 from Europe and one from Japan, reported on and discussed such topics as theoretical and experimental ion optics and new methods for the mass analysis of ions.

The general theme of the first morning and afternoon sessions was mass spectroscopy of high resolution for the accurate measurement of atomic masses. The opening paper, presented by J. Mattauch (Max Planck Institute, Mainz, Germany), reviewed previous advances in mass spectroscopy. K. T. Bainbridge (Harvard Univ.) then described a table of masses derived from recent doublet and Q measurements. An evening session was needed to complete an extensive program on the problems of increasing the intensity and resolution, and consequently the accuracy, of mass measurements. These sessions were particularly fruitful because they provided a mechanism whereby the European and American scientists could compare notes and obtain first-hand information on experiments in progress.

The sessions held on the second day were devoted to experiments in cyclotron resonance conducted by the Brookhaven National Laboratories and the National Bureau of Standards. Discussions were also held on the problems associated with the studies of isotopic abundance.

The fifth session included a paper by M. G. Inghram (University of Chicago) on the use of the mass spectrometer as a tool for studying nuclear reactions. J. Koch (Copenhagen) and J. Kistemaker (Amsterdam) presented individual reviews of isotope separators. The papers for the sixth session had for their themes ionization and dissociation by electron impact as revealed by the mass spectrometer, the effects of space charge, and studies of solids.

The final session of the symposium was devoted to a general discussion of experimental methods in which most of the attending physicists actively participated. Professor A. O. C. Nier (University of Minnesota) arranged the session and was discussion leader. Included among the topics were questions and answers arising out of the papers presented during the preceding six sessions, as well as special discussions on ion sources, secondary emission, multipliers, and special materials and mounts for electrodes.

International Commission on Illumination

At the recent Annual Meeting of the U. S. National Committee of the International Commission on Illumination, the recommendations tentatively adopted at the Twelfth Session of the Commission in Stockholm, Sweden, on June 26 to July 7, 1951, were, with few exceptions, confirmed. In attendance at the Stockholm Sessions were 450 delegates from 22 countries. The United States was represented by 18 delegates, among whom were L. E. Barbrow, F. C. Breckenridge, and D. B. Judd of the National Bureau of Standards.

Most important among the confirmed recommendations were the following: (1) The adoption of a relative luminosity curve for the dark-adapted human eye near the threshold in extra-foveal vision. (2) A new definition of standard source A which fixes the spectral energy distribution of this source regardless of how the constant C_2 of Planck may be changed. (3) A procedure for comparing the performance of European and American automobile headlights preliminary to proposing a world agreement based on technical requirements for the passing beam of headlights. (4) International definitions of five signal colors (red, yellow, green, blue and white), suitable for general signal purposes and additional definitions for red, green and blue lights designed to assure a high certainty of recognition of the signal color.

In addition to these definitive recommendations, the research required to solve urgent problems in illuminating engineering was planned. Studies have been started that are expected to lead at the next meeting in 1955 to the adoption of a more accurate standard observer and relative luminosity curve for the light-adapted human eye and to a coordinate system for colorimetry which will express color differences more faithfully. Extensive studies were also planned to

determine the color-rendering properties of fluorescent lamps and to develop an international method for specifying such properties.

Dr. Judd presented a report on colorimetry which included recommendations for changes in the luminosity curve of the light-adapted eye as well as a resumé of methods for specifying the color-rendering properties of light sources. Mr. Breckenridge represented the United States in the development of recommendations for the colors of light signals and in the study of the required characteristics of approach-light systems. Secretary of the U. S. Delegation was Mr. Barbrow, who also served as a member of the Executive Committee of the Commission which formulated the policies that will guide the Commission until its next session in Switzerland during 1955.

Publications of the National Bureau of Standards

Periodicals

Journal of Research of the National Bureau of Standards, volume **48,** number 1, January 1952 (RP2279 to RP2290, incl.)

Technical News Bulletin, volume **36,** number 1, January 1952. 10 cents.

CRPL–D89. Basic Radio Propagation Predictions for April 1952. Three months in advance. Issued January 1952. 10 cents.

Research Papers

Reprints from Journal of Research, volume **47,** *No. 6, December 1951*

RP2268. pH of solutions of potassium hydrogen *d*-tartrate from 0° to 60° C. Roger G. Bates, Vincent E. Bower, Richard G. Miller, and Edgar R. Smith.

RP2269. Heats of formation of some barium aluminates. R. B. Peppler and E. S. Newman.

RP2270. Thickness of glass electrodes. J. J. Diamond and Donald Hubbard.

RP2271. Some characteristics of Stedman packing in the distillation of hydrogen and its isotopes. Abraham Fookson, Philip Pomrantz, and Simon Rothberg.

RP2272. Use of radiation from incandescent particles as an indication of flame temperature. Earle K. Plyler and Curtis J. Humphreys.

RP2273. Electron-optical bench. L. Marton, M. M. Morgan, D. C. Schubert, J. R. Shah, and J. A. Simpson.

RP2274. Random determinants. R. Fortet.

RP2275. Solutions of Ax-λBx. M. R. Hestenes and W. Karush.

RP2276. Proposed revision of the conventional method of wave-filter design. Paul J. Selgin.

RP2277. On the derivation and accuracy of certain formulas for sample sizes and operation characteristics of nonsequential sampling procedures. Uttam Chand.

RP2278. Asymmetries of Zeeman patterns and *g*-values for neutral manganese. Miguel A. Catalan.

Circulars

C499 (Supplement No. 2). Nuclear data (July 1950 to January 1951). (Second of three supplements that will be mailed automatically to purchasers of Circular 499.) Price, Circular 499 and three supplements, $4.25.

Handbooks

H48. Control and removal of radioactive contamination in laboratories. 15 cents.

Publications in Other Journals

Proposals for the mechanical resolution of German syntax patterns. Victor A. Oswald, Jr. and Stuart L. Fletcher, Jr. Modern Language Forum (Modern Language Assoc. of Southern California, Los Angeles, Calif.) **36,** No. 3–4, 1 (1951).

Change of free energy with pressure of the reaction nepheline+albite=2 jadeite. H. S. Yoder (Geophysical Laboratory, Carnegie Institution of Washington) and C. E. Weir (NBS). Am. J. Sci. (Sterling Tower, New Haven, Conn.) **249,** 683, (Sept. 1951).

Influence of the sun upon the ionosphere. Newbern Smith. Part of a Conference on the sun in the service of man. Proc. American Academy of Arts and Sciences. (28 Newbury St., Boston 16, Mass.) **79,** No. 4, 254 (July 1951).

The interpretation of chemical data. W. J. Youden. Conference Papers of the American Society for Quality Control (1951). The Conference Papers are available from the American Society for Quality Control (Rochester Institute of Technology, Rochester 8, N. Y.), $3.50 a volume.

Directional distribution of 1040-Kev radiation from a high voltage x-ray tube. N. Goldstein, U. Fano, and H. O. Wyckoff. J. App. Phys. (57 East Fifty-fifth Street, New York 22, N. Y.) **22,** 417 (April 1951).

Special lubricants tests. H. S. White and D. Zei. Mechanical Eng. (29 West Thirty-ninth Street, New York 18, N. Y.) **73,** 657 (August 1951).

Evaluation of automatic computing machines. Franz Alt. Pro. Eng. (330 W. Forty-second Street, New York 18, N. Y.) **22,** 146 (November 1951).

Preservation of the Declaration of Independence and the Constitution of the United States. Gordon M. Kline. ASTM Bulletin (1916 Race Street, Philadelphia 3, Pa.) No. 178, 32 (December 1951).

Aviation instruments. W. G. Brombacher. Chapter in the Handbook of Measurement and Control. Instruments (921 Ridge Ave., Pittsburgh 12, Pa.).

The relation between the absorption spectra and the chemical constitution of dyes. XXIV. Absorption spectra of some thioindigo dyes in sulfuric acid. Wallace R. Brode and George M. Wyman. J. Am. Chem. Soc. (1155 Sixteenth Street NW., Washington 6, D. C.) **73,** 4267 (1951).

Tuning systems employing feedback amplifiers. Peter G. Sulzer. Electronics (330 West Forty-second Street, New York 18, N. Y.) **24,** 252 (March 1951).

R–F solenoid design chart. Peter G. Sulzer. Tele-Tech (480 Lexington Avenue, New York 17, N. Y.) **10,** 45 (May 1951).

An iterative method for finding characteristic vectors of a symmetric matrix. W. Karush. Pacific J. Math. (University of California at Los Angeles, Los Angeles, Calif.) **1,** No. 2, 233 (June 1951).

The cascaded binary counter with feedback. G. Franklin Montgomery. J. App. Phy. (57 East Fifty-fifth Street, New York 22, N. Y.) **22,** 780 (June 1951).

Notes for numerical analysis 5. Table-making for large arguments. The exponential integral. L. Fox and J. C. P. Miller. Math. Tables and Other Aids to Computation (2101 Constitution Avenue NW, Washington 25, D. C.) **35,** 163 (July 1951).

Publications for which a price is indicated are available only from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (Foreign postage, one-third additional). Reprints from outside journals are not available from the National Bureau of Standards, but can often be obtained from the publishers.

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